

TLV431A

Low Voltage Precision Adjustable Shunt Regulator

The TLV431A series are precision low voltage shunt regulators that are programmable over a wide voltage range of 1.24 V to 16 V. These series feature a guaranteed reference accuracy of $\pm 1.0\%$ at 25°C and $\pm 2.0\%$ over the entire industrial temperature range of -40°C to 85°C . These devices exhibit a sharp low current turn-on characteristic with a low dynamic impedance of $0.20\ \Omega$ over an operating current range of $100\ \mu\text{A}$ to $20\ \text{mA}$. This combination of features makes this series an excellent replacement for zener diodes in numerous applications circuits that require a precise reference voltage. When combined with an optocoupler, the TLV431A can be used as an error amplifier for controlling the feedback loop in isolated low output voltage (3.0 V to 3.3 V) switching power supplies. These devices are available in economical TSOP-5 and TO-92 packages.

Features

- Programmable Output Voltage Range of 1.24 V to 16 V
- Voltage Reference Tolerance $\pm 1.0\%$
- Sharp Low Current Turn-On Characteristic
- Low Dynamic Output Impedance of $0.20\ \Omega$ from $100\ \mu\text{A}$ to $20\ \text{mA}$
- Wide Operating Current Range of $50\ \mu\text{A}$ to $20\ \text{mA}$
- Micro Miniature TSOP-5 and TO-92 Packages

Applications

- Low Output Voltage (3.0 V to 3.3 V) Switching Power Supply Error Amplifier
- Adjustable Voltage or Current Linear and Switching Power Supplies
- Voltage Monitoring
- Current Source and Sink Circuits
- Analog and Digital Circuits Requiring Precision References
- Low Voltage Zener Diode Replacements

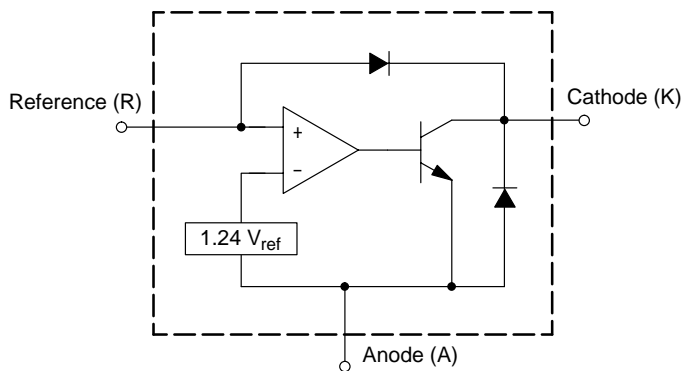


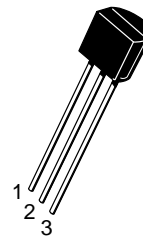
Figure 1. Representative Block Diagram



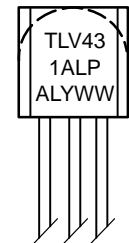
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MARKING DIAGRAM

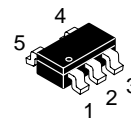


TO-92
LP SUFFIX
CASE 29



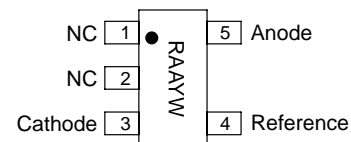
1. Reference
2. Anode
3. Cathode

A = Assembly Location
L = Wafer Lot
Y = Year
WW = Work Week



TSOP-5
SN SUFFIX
CASE 483

PIN CONNECTIONS AND DEVICE MARKING



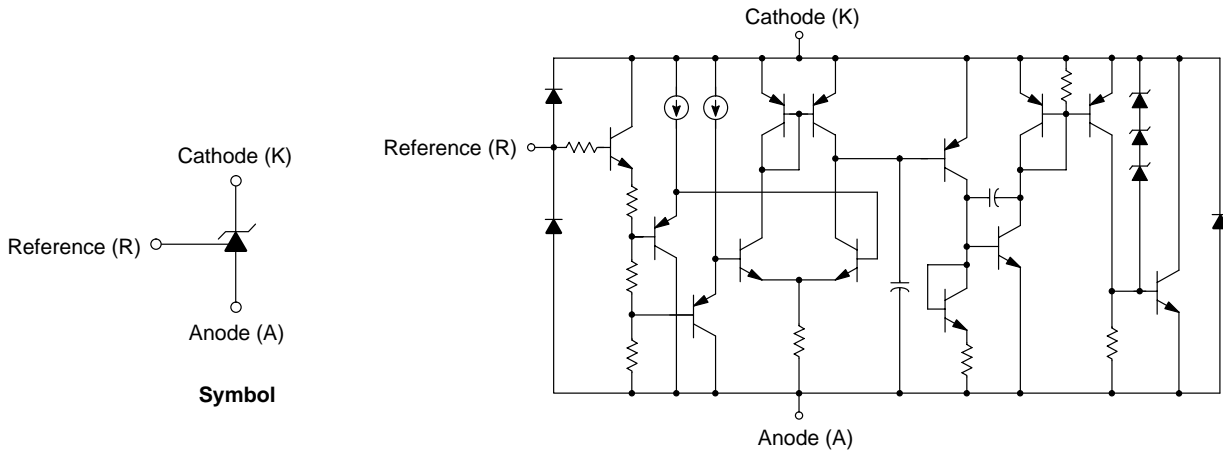
(Top View)

RAA = Device Code
Y = Year
W = Work Week

ORDERING INFORMATION

Device	Package	Shipping
TLV431ALP	TO-92	6000 / Box
TLV431ALPRA	TO-92	2000 / Tape & Reel
TLV431ALPRE	TO-92	2000 / Tape & Reel
TLV431ALPRM	TO-92	2000 / Ammo Pack
TLV431ALPRP	TO-92	2000 / Ammo Pack
TLV431ASNT1	TSOP-5	3000 / Tape & Reel

TLV431A



The device contains 13 active transistors.

Figure 2. Representative Schematic Diagram

MAXIMUM RATINGS (Full operating ambient temperature range applies, unless otherwise noted)

Rating	Symbol	Value	Unit
Cathode to Anode Voltage	V_{KA}	18	V
Cathode Current Range, Continuous (Note 1.)	I_K	-20 to 25	mA
Reference Input Current Range, Continuous	I_{ref}	-0.05 to 10	mA
Thermal Characteristics			°C/W
LP Suffix Package			
Thermal Resistance, Junction-to-Ambient	$R_{\theta JA}$	178	
Thermal Resistance, Junction-to-Case	$R_{\theta JC}$	83	
SN Suffix Package			
Thermal Resistance, Junction-to-Ambient	$R_{\theta JA}$	226	
Operating Junction Temperature	T_J	150	°C
Operating Ambient Temperature Range (Note 1.)	T_A	-40 to 85	°C
Storage Temperature Range	T_{stg}	-65 to 150	°C

1. Maximum package power dissipation limits must not be exceeded.

$$P_D = \frac{T_{J(max)} - T_A}{R_{\theta JA}}$$

NOTE: This device series contains ESD protection and exceeds the following tests:
 Human Body Model 2000 V per MIL-STD-883, Method 3015.
 Machine Model Method 200 V.

RECOMMENDED OPERATING CONDITIONS

Condition	Symbol	Min	Max	Unit
Cathode to Anode Voltage	V_{KA}	V_{ref}	16	V
Cathode Current	I_K	0.1	20	mA

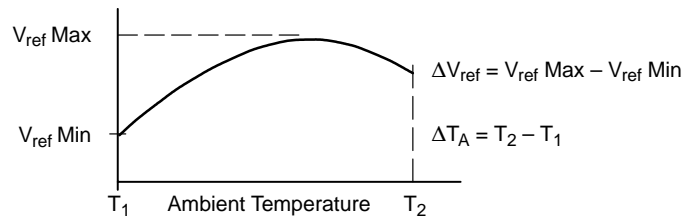
TLV431A

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Typ	Max	Unit
Reference Voltage (Figure 1) (V _{KA} = V _{ref} , I _K = 10 mA, T _A = 25°C) (T _A = T _{low} to T _{high} , Note 2.)	V _{ref}	1.228 1.215	1.240 —	1.252 1.265	V
Reference Input Voltage Deviation Over Temperature (Figure 1) (V _{KA} = V _{ref} , I _K = 10 mA, T _A = T _{low} to T _{high} , Notes 2., 3.)	ΔV _{ref}	—	7.2	20	mV
Ratio of Reference Input Voltage Change to Cathode Voltage Change (Figure 2) (V _{KA} = V _{ref} to 16 V, I _K = 10 mA)	$\frac{\Delta V_{ref}}{\Delta V_{KA}}$	—	−0.6	−1.5	$\frac{mV}{V}$
Reference Terminal Current (Figure 2) (I _K = 10 mA, R1 = 10 kΩ, R2 = open)	I _{ref}	—	0.15	0.3	μA
Reference Input Current Deviation Over Temperature (Figure 2) (I _K = 10 mA, R1 = 10 kΩ, R2 = Open, Notes 2., 3.)	ΔI _{ref}	—	0.04	0.08	μA
Minimum Cathode Current for Regulation (Figure 1)	I _{K(min)}	—	55	80	μA
Off-State Cathode Current (Figure 3) (V _{KA} = 6.0 V, V _{ref} = 0) (V _{KA} = 16 V, V _{ref} = 0)	I _{K(off)}	— —	0.01 0.012	0.04 0.05	μA
Dynamic Impedance (Figure 1) (V _{KA} = V _{ref} , I _K = 0.1 mA to 20 mA, f ≤ 1.0 kHz, Note 4.)	Z _{KA}	—	0.25	0.4	Ω

2. Ambient temperature range: T_{low} = −40°C, T_{high} = 85°C.

3. The deviation parameters ΔV_{ref} and ΔI_{ref} are defined as the difference between the maximum value and minimum value obtained over the full operating ambient temperature range that applied.



The average temperature coefficient of the reference input voltage, αV_{ref} is defined as:

$$\alpha V_{ref} \left(\frac{\text{ppm}}{^{\circ}\text{C}} \right) = \frac{\left(\frac{\Delta V_{ref}}{V_{ref} (T_A = 25^{\circ}\text{C})} \times 10^6 \right)}{\Delta T_A}$$

αV_{ref} can be positive or negative depending on whether V_{ref} Min or V_{ref} Max occurs at the lower ambient temperature, refer to Figure 6.

Example: ΔV_{ref} = 7.2 mV and the slope is positive,

$$V_{ref} @ 25^{\circ}\text{C} = 1.241 \text{ V}$$

$$\Delta T_A = 125^{\circ}\text{C}$$

$$\alpha V_{ref} \left(\frac{\text{ppm}}{^{\circ}\text{C}} \right) = \frac{0.0072 \times 10^6}{1.241 \times 125} = 46 \text{ ppm}/^{\circ}\text{C}$$

4. The dynamic impedance Z_{KA} is defined as:

$$|Z_{KA}| = \frac{\Delta V_{KA}}{\Delta I_K}$$

When the device is operating with two external resistors, R1 and R2, (refer to Figure 2) the total dynamic impedance of the circuit is given by:

$$|Z_{KA}'| = |Z_{KA}| \times \left(1 + \frac{R1}{R2} \right)$$

TLV431A

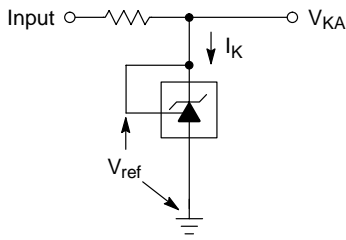


Figure 1. Test Circuit for $V_{KA} = V_{ref}$

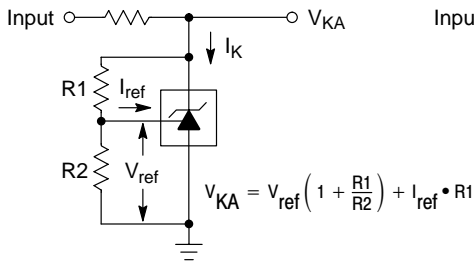


Figure 2. Test Circuit for $V_{KA} > V_{ref}$

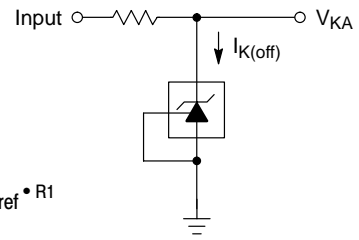


Figure 3. Test Circuit for $I_{K(off)}$

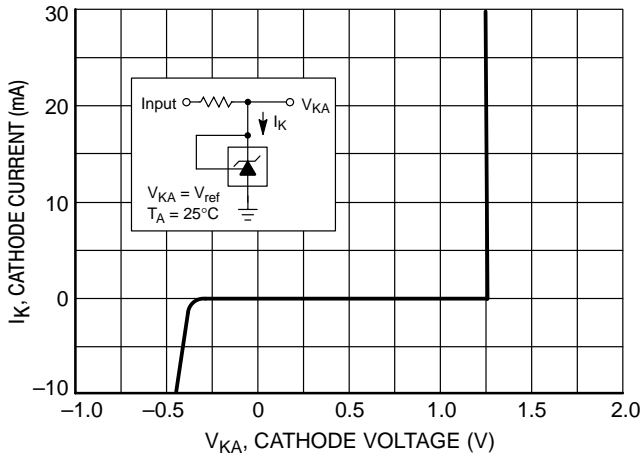


Figure 4. Cathode Current vs. Cathode Voltage

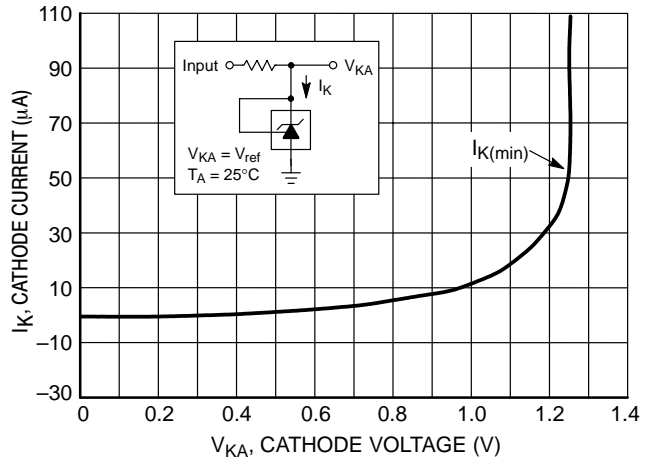


Figure 5. Cathode Current vs. Cathode Voltage

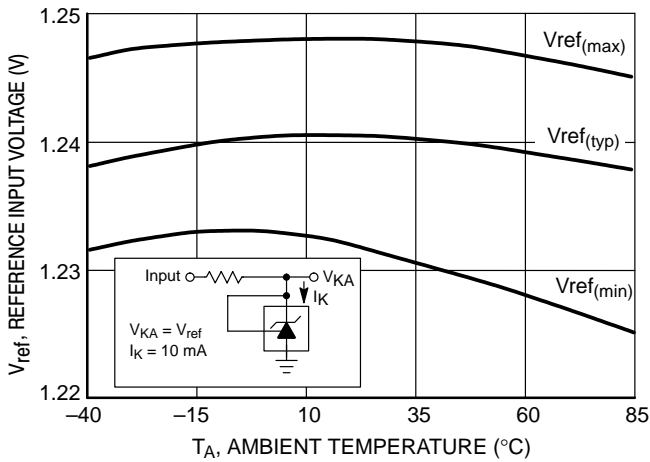


Figure 6. Reference Input Voltage versus Ambient Temperature

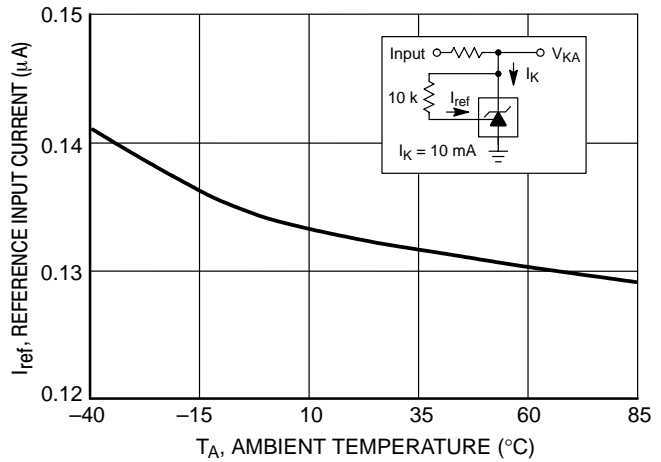


Figure 7. Reference Input Current versus Ambient Temperature

TLV431A

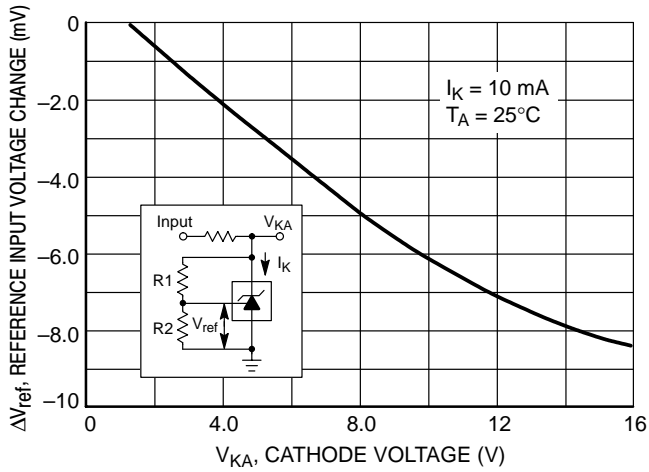


Figure 8. Reference Input Voltage Change versus Cathode Voltage

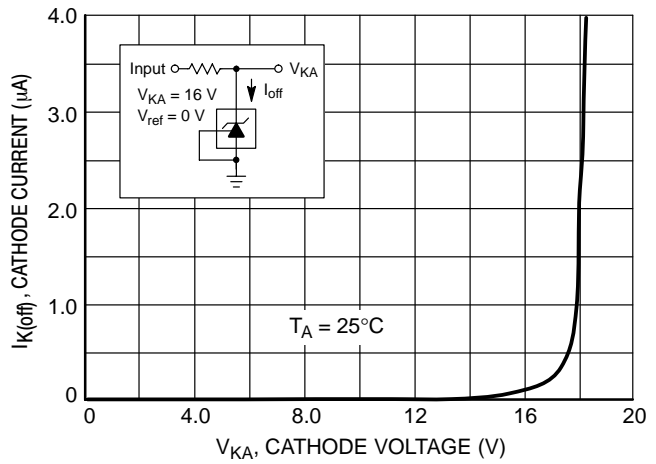


Figure 9. Off-State Cathode Current versus Cathode Voltage

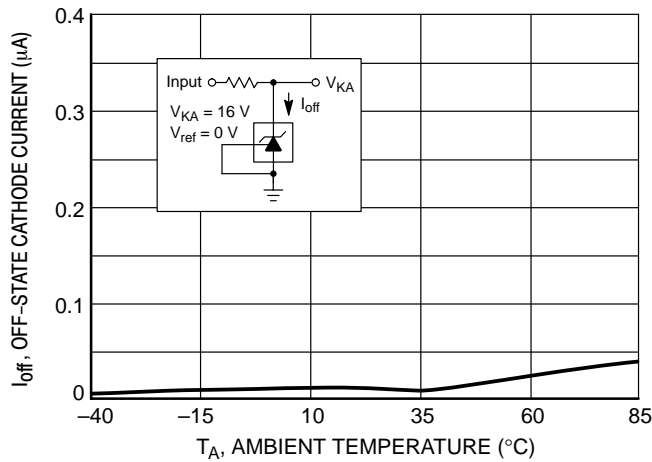


Figure 10. Off-State Cathode Current versus Ambient Temperature

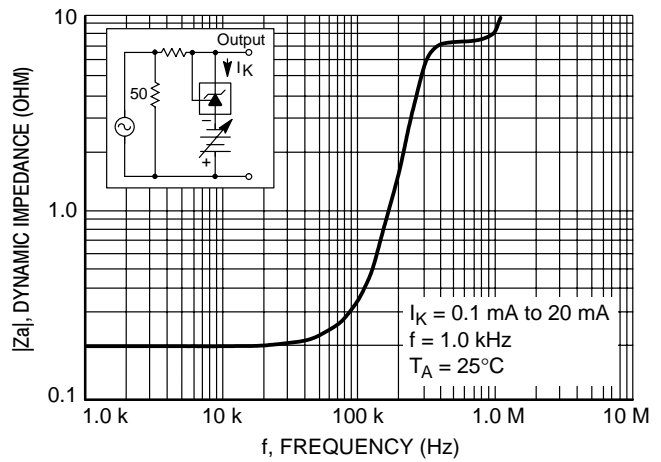


Figure 11. Dynamic Impedance versus Frequency

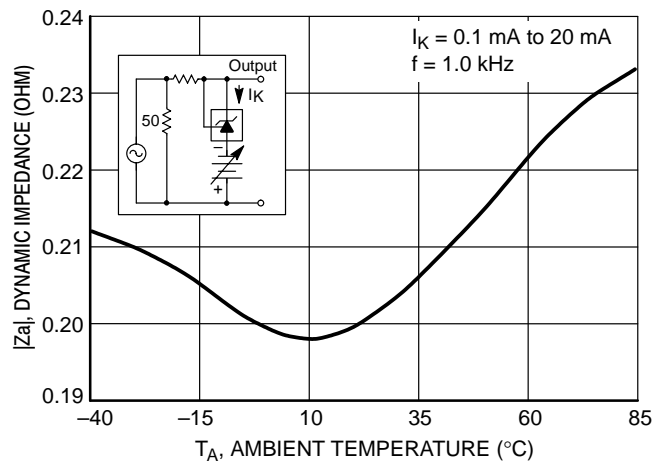


Figure 12. Dynamic Impedance versus Ambient Temperature

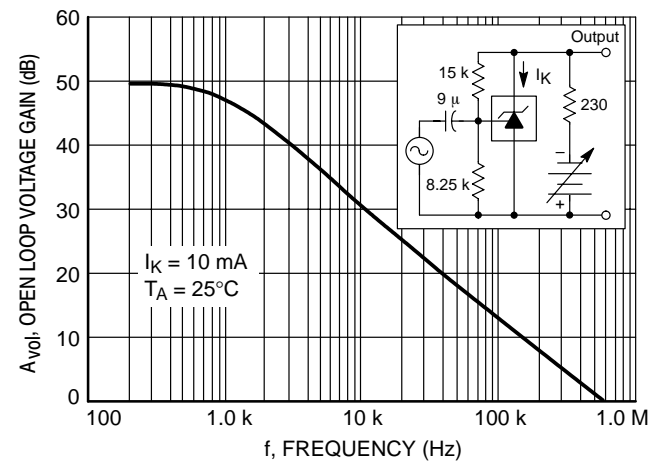


Figure 13. Open-Loop Voltage Gain versus Frequency

TLV431A

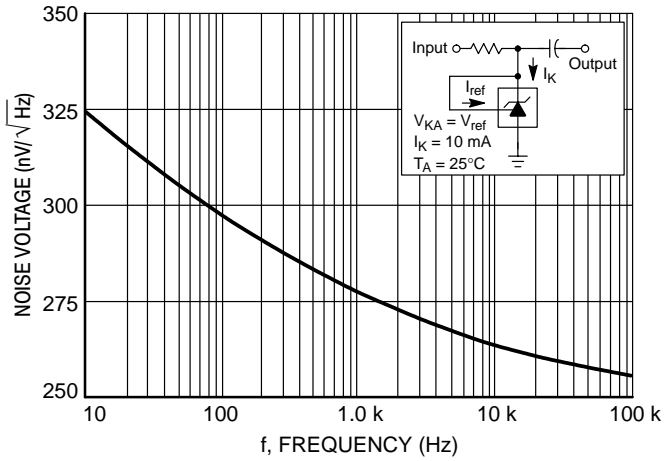


Figure 14. Spectral Noise Density

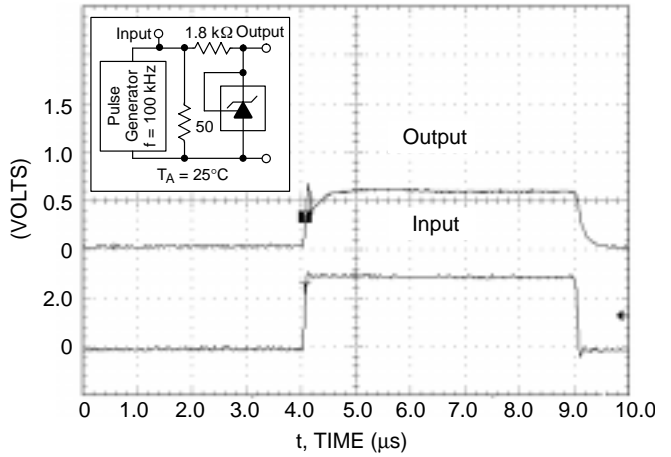


Figure 15. Pulse Response

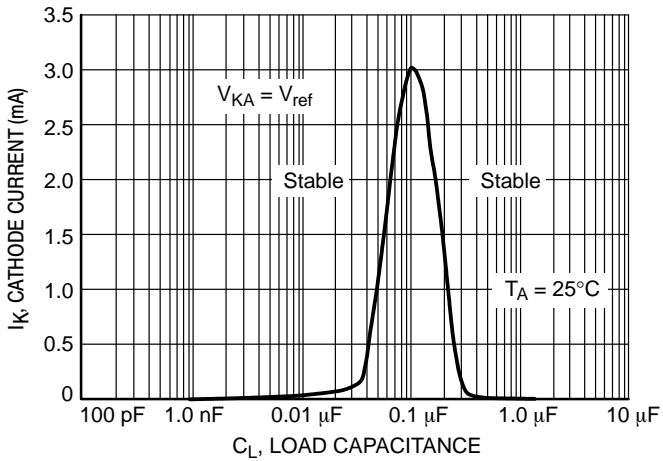


Figure 16. Stability Boundary Conditions

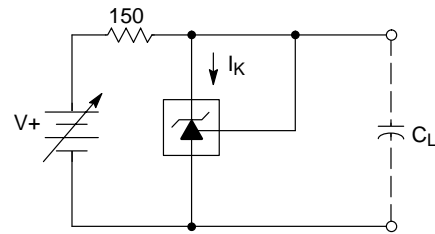


Figure 17. Test Circuit for Figure 16

TYPICAL APPLICATIONS

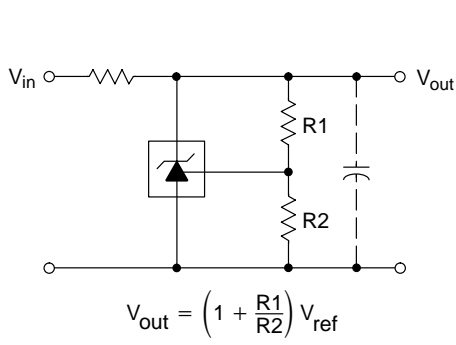


Figure 18. Shunt Regulator

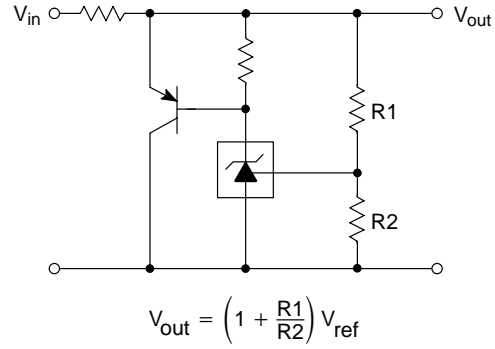


Figure 19. High Current Shunt Regulator

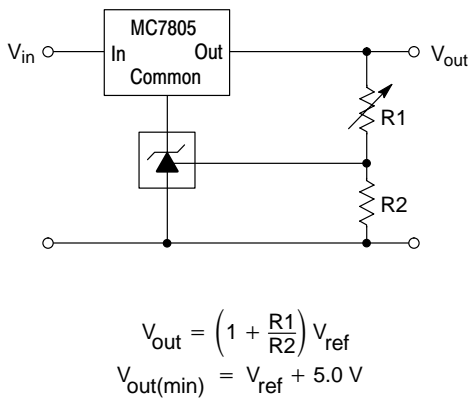


Figure 20. Output Control for a Three Terminal Fixed Regulator

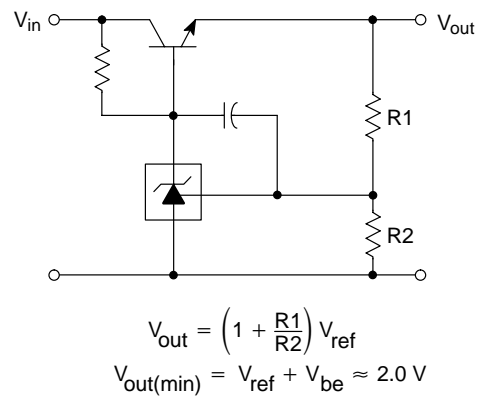


Figure 21. Series Pass Regulator

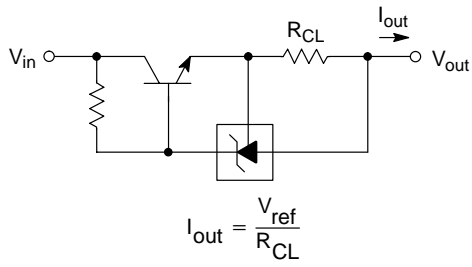


Figure 22. Constant Current Source

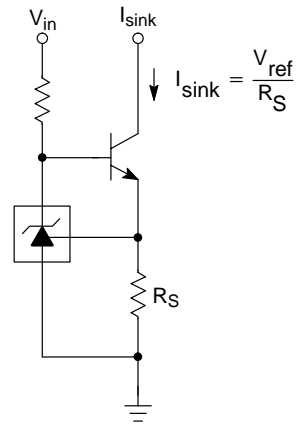


Figure 23. Constant Current Sink

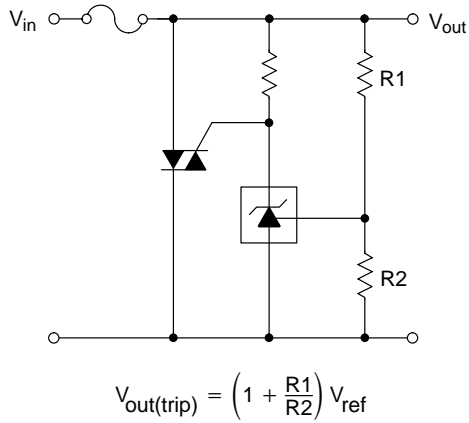


Figure 24. TRIAC Crowbar

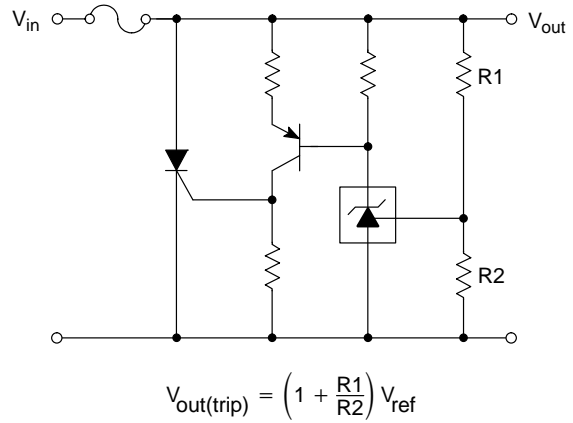
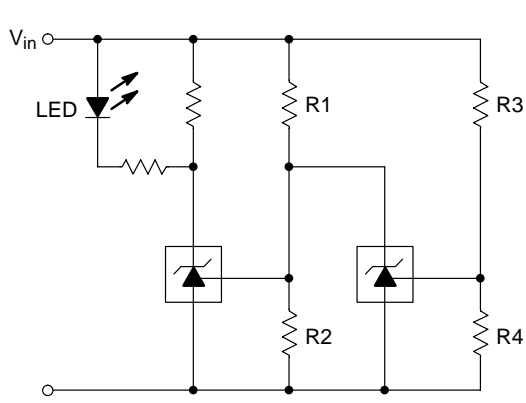


Figure 25. SCR Crowbar

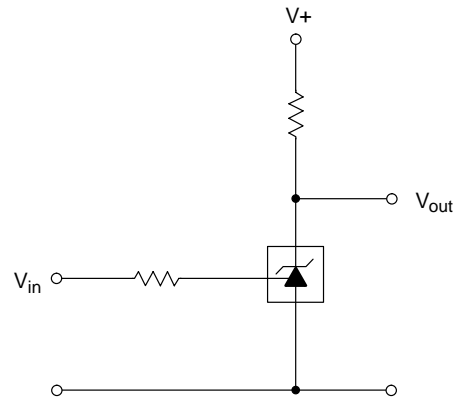


L.E.D. indicator is 'ON' when V_{in} is between the upper and lower limits,

$$\text{Lower limit} = \left(1 + \frac{R1}{R2}\right) V_{ref}$$

$$\text{Upper limit} = \left(1 + \frac{R3}{R4}\right) V_{ref}$$

Figure 26. Voltage Monitor



V_{in}	V_{out}
$< V_{ref}$	$V+$
$> V_{ref}$	$\approx 0.74 V$

Figure 27. Single-Supply Comparator with Temperature-Compensated Threshold

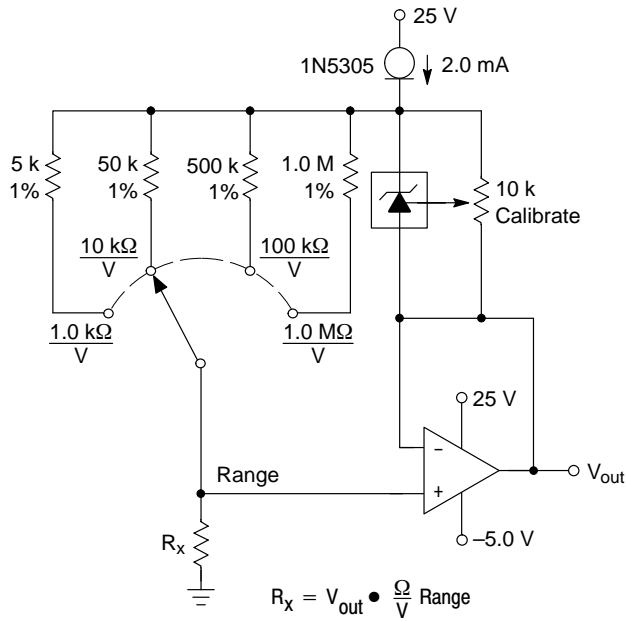
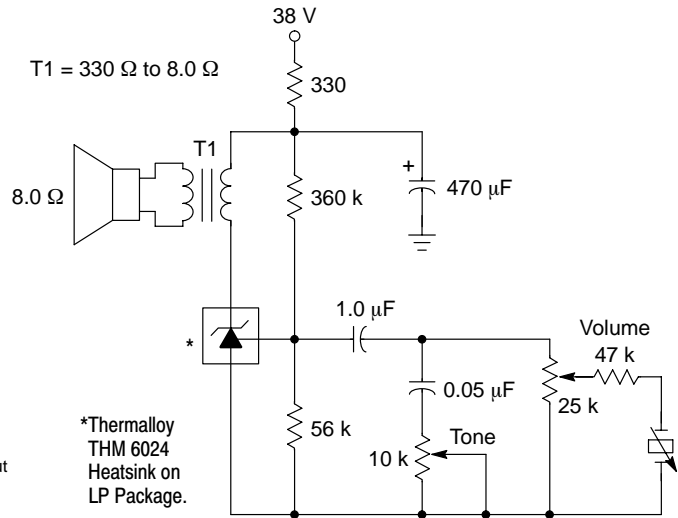


Figure 28. Linear Ohmmeter



*Thermalloy THM 6024 Heatsink on LP Package.

Figure 29. Simple 400 mW Phono Amplifier

TLV431A

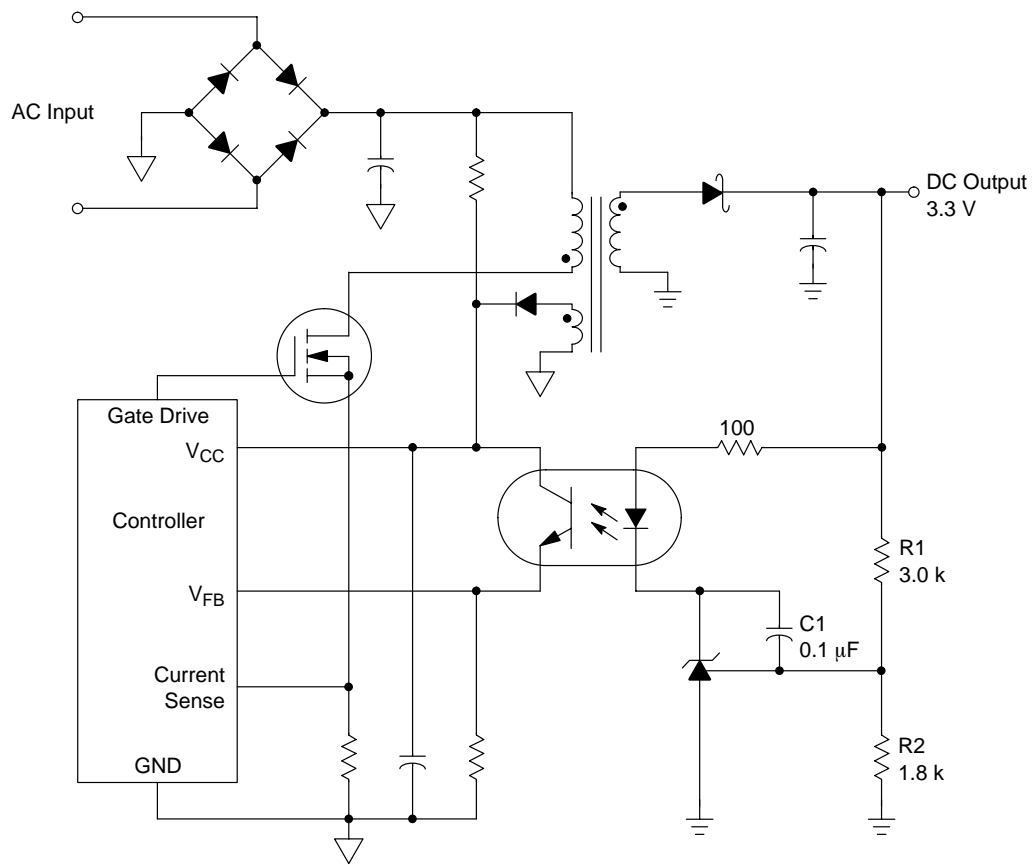


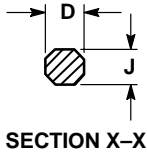
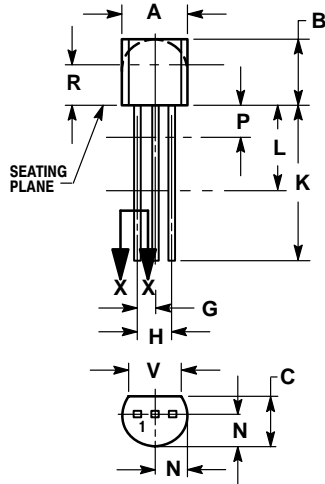
Figure 30. Isolated Output Line Powered Switching Power Supply

The above circuit shows the TLV431A as a compensated amplifier controlling the feedback loop of an isolated output line powered switching regulator. The output voltage is programmed to 3.3 V by the resistors values selected for R1 and R2. The minimum output voltage that can be programmed with this circuit is 2.64 V, and is limited by the sum of the reference voltage (1.24 V) and the forward drop of the optocoupler light emitting diode (1.4 V). Capacitor C1 provides loop compensation.

TLV431A

PACKAGE DIMENSIONS

TO-92
LP SUFFIX
PLASTIC PACKAGE
CASE 29-11
ISSUE AJ

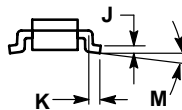
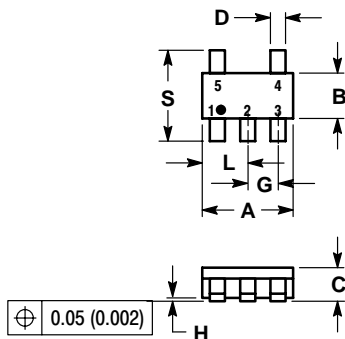


NOTES:

1. DIMENSIONING AND TOLERANCING PER ANSI Y14.5M, 1982.
2. CONTROLLING DIMENSION: INCH.
3. CONTOUR OF PACKAGE BEYOND DIMENSION R IS UNCONTROLLED.
4. LEAD DIMENSION IS UNCONTROLLED IN P AND BEYOND DIMENSION K MINIMUM.

DIM	INCHES		MILLIMETERS	
	MIN	MAX	MIN	MAX
A	0.175	0.205	4.45	5.20
B	0.170	0.210	4.32	5.33
C	0.125	0.165	3.18	4.19
D	0.016	0.021	0.407	0.533
G	0.045	0.055	1.15	1.39
H	0.095	0.105	2.42	2.66
J	0.015	0.020	0.39	0.50
K	0.500	---	12.70	---
L	0.250	---	6.35	---
N	0.080	0.105	2.04	2.66
P	---	0.100	---	2.54
R	0.115	---	2.93	---
V	0.135	---	3.43	---

TSOP-5
SN SUFFIX
PLASTIC PACKAGE
CASE 483-01
ISSUE A



NOTES:

1. DIMENSIONING AND TOLERANCING PER ANSI Y14.5M, 1982.
2. CONTROLLING DIMENSION: MILLIMETER.
3. MAXIMUM LEAD THICKNESS INCLUDES LEAD FINISH THICKNESS. MINIMUM LEAD THICKNESS IS THE MINIMUM THICKNESS OF BASE MATERIAL.

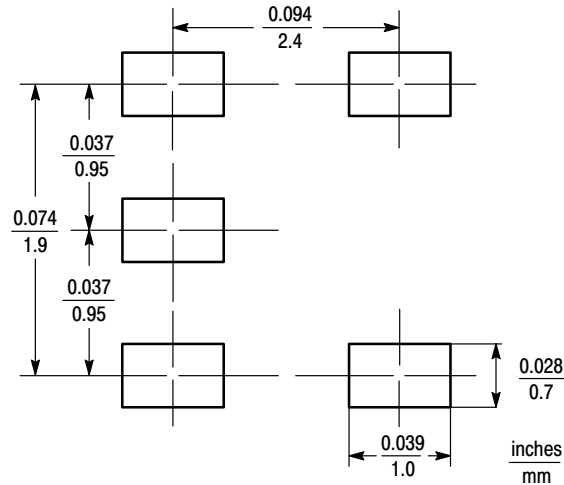
DIM	MILLIMETERS		INCHES	
	MIN	MAX	MIN	MAX
A	2.90	3.10	0.1142	0.1220
B	1.30	1.70	0.0512	0.0669
C	0.90	1.10	0.0354	0.0433
D	0.25	0.50	0.0098	0.0197
G	0.85	1.00	0.0335	0.0413
H	0.013	0.100	0.0005	0.0040
J	0.10	0.26	0.0040	0.0102
K	0.20	0.60	0.0079	0.0236
L	1.25	1.55	0.0493	0.0610
M	0°	10°	0°	10°
S	2.50	3.00	0.0985	0.1181

TLV431A


MINIMUM RECOMMENDED FOOTPRINT FOR SURFACE MOUNTED APPLICATIONS

Surface mount board layout is a critical portion of the total design. The footprint for the semiconductor packages must be the correct size to insure proper solder connection

interface between the board and the package. With the correct pad geometry, the packages will self align when subjected to a solder reflow process.



TSOP-5
(Footprint Compatible with SOT-23-5)

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